Chapter 4
SELECTING BEST MANAGEMENT PRACTICES

4.1 Temporary Versus Permanent BMPs

The same level of care should be taken to select temporary BMPs as well as permanent BMPs. The same level of care should also be taken to install and maintain temporary BMPs. The only difference is in the intended lifespan of the BMP. It is good to remember that, in the world of construction and industry, a temporary solution may be in place for years and years due to oversight, neglect, good performance, etc. In general, temporary BMPs are intended to address construction activities; while permanent BMPs address long-term stormwater management objectives.

Temporary BMPs may include a variety of “good housekeeping” measures and short-term erosion and sediment control activities. An appropriate professional such as construction site operator and/or licensed professional civil engineer should utilize temporary BMPs. A licensed professional engineer must design some of the more complicated or sensitive BMPs. The temporary management practices should be designed and submitted to the plan review process with the City of Knoxville Engineering Department. The contractor is responsible for properly constructing/implementing and maintaining the temporary practices and/or seeking guidance when the measures do not appear to be meeting the stormwater management objectives (namely that sediment and other pollutants do not leave the construction site).

Permanent BMPs, which are designed to control long-term stormwater pollution, are the final improvements to and configuration of the project. Permanent BMPs are selected by licensed professional civil engineers, incorporated into the plans and specifications for the project, and have long-term maintenance responsibilities identified. The contractor is responsible for properly constructing the permanent controls. Permanent BMPs are normally selected in the planning phase in conjunction with the approval of the tentative map designed during the design phase of a project and completed to the satisfaction of the City of Knoxville Engineering Department. Occasionally, unforeseen natural or manmade factors may require revisions to or additions of permanent BMPs during the construction phase. These revisions or additions must be also be approved by the City of Knoxville Engineering Department.

4.2 Identify Objectives

The objectives in pollution prevention for each property can vary widely. Therefore, a specific understanding of pollution risks for each activity is essential for selecting and implementing BMPs. Defining these risks requires review of the characteristics of the site and the nature of the construction process or industrial activity. This information should be carefully assembled and reviewed early in the design process. Once these pollution risks are defined, then BMP objectives are developed and specific BMPs can be selected. The BMP objectives for a typical construction project are as follows:

- Practice Good Housekeeping: Perform activities in a manner, which keeps potential pollutants from either draining or being transported offsite by managing pollutant sources and modifying construction activities. Dispose of waste materials in designated areas and in designated containers away from rainfall and stormwater runoff.

- Minimize Disturbed Areas: Only clear land that will be actively under construction in the near term (within the next 3 months). Minimize new land disturbance, and do not clear or disturb sensitive areas (e.g., steep slopes, buffers and natural watercourses).
- Stabilize Disturbed Areas: Provide temporary stabilization of disturbed soils whenever active construction is not occurring on that portion of the site. Provide permanent stabilization during the final grading process and carefully landscape the site.
- Protect Slopes and Channels: Avoid disturbing steep or unstable slopes. Safely convey runoff from the top of the slope and stabilize disturbed slopes as quickly as possible. Avoid disturbing natural channels. Stabilize temporary and permanent channel crossings as quickly as possible and ensure that increases in runoff velocity caused by the project do not erode the channel.
- Control Site Perimeter: Upstream runoff should be diverted around or safely conveyed through the construction project, and must not cause downstream property damage. Runoff from project site should be free of excessive sediment and other constituents.
- Control Internal Erosion and Drainage: Detain sediment-laden waters from actively disturbed areas within the site to minimize the risk that sediment will have the opportunity to leave the site.

BMP objectives for an industrial or commercial facility already in operation will basically have all of the same BMP objectives. But there will be a different amount of emphasis placed on good housekeeping, institutional controls and procedures, good training methods and regular refresher classes, and using the best available technology. BMP objectives in this chapter are generally discussed from a construction point of view, but are applicable to all types of land uses. See Section 4.5 for pollution removal goals, and see Chapter 6 for pollution prevention plans for industrial and commercial sites.

Site characteristics and proposed contractor activities will affect the potential for site erosion and contamination by other constituents used on the construction site. It is important to plan the project to fit the topography and drainage patterns of the site. Before defining BMP objectives, these factors should be carefully considered:

1. Site conditions that affect erosion and sedimentation, which include:
   a. Soil type, including underlying soil strata that are likely to be exposed
   b. Natural terrain and slope
   c. Final slopes and grades
   d. Location of concentrated flows, storm drains, and streams
   e. Existing vegetation and ground cover
2. Climatic factors, which include:
   a. Seasonal rainfall patterns
   b. Appropriate design storm (quantity, intensity, duration)
3. Type of construction activity.
4. Construction schedules, construction sequencing, and phasing of construction.
5. Size of construction project and area to be graded.
6. Location of the construction activity relative to adjacent uses and public improvements.
7. Cost-effectiveness considerations.

8. Types of construction materials and potential pollutants present or that will be brought on-site.

9. Floodplain, floodway, and buffer requirements.

4.3 Select BMPs

Once the BMP objectives are defined, it is necessary to identify the BMPs that are best suited to meet each objective. To determine where to place BMPs, a map of the project site can be prepared with sufficient topographic detail to show existing and proposed drainage patterns and existing and proposed permanent stormwater control structures. The project site map should identify the following:

- Locations where stormwater enters and exits the site. Include both sheet and channel flow for the existing and final grading contours.

- Identify locations subject to high rates of erosion such as steep slopes and unlined channels. Long, steep slopes over 100 feet in length are considered as areas of moderate to high erosion potential.

- Categorize slopes as: low erosion potential (0 to 5 percent slope), moderate erosion potential (5 to 10 percent slope), or high erosion potential (slope greater than 10 percent).

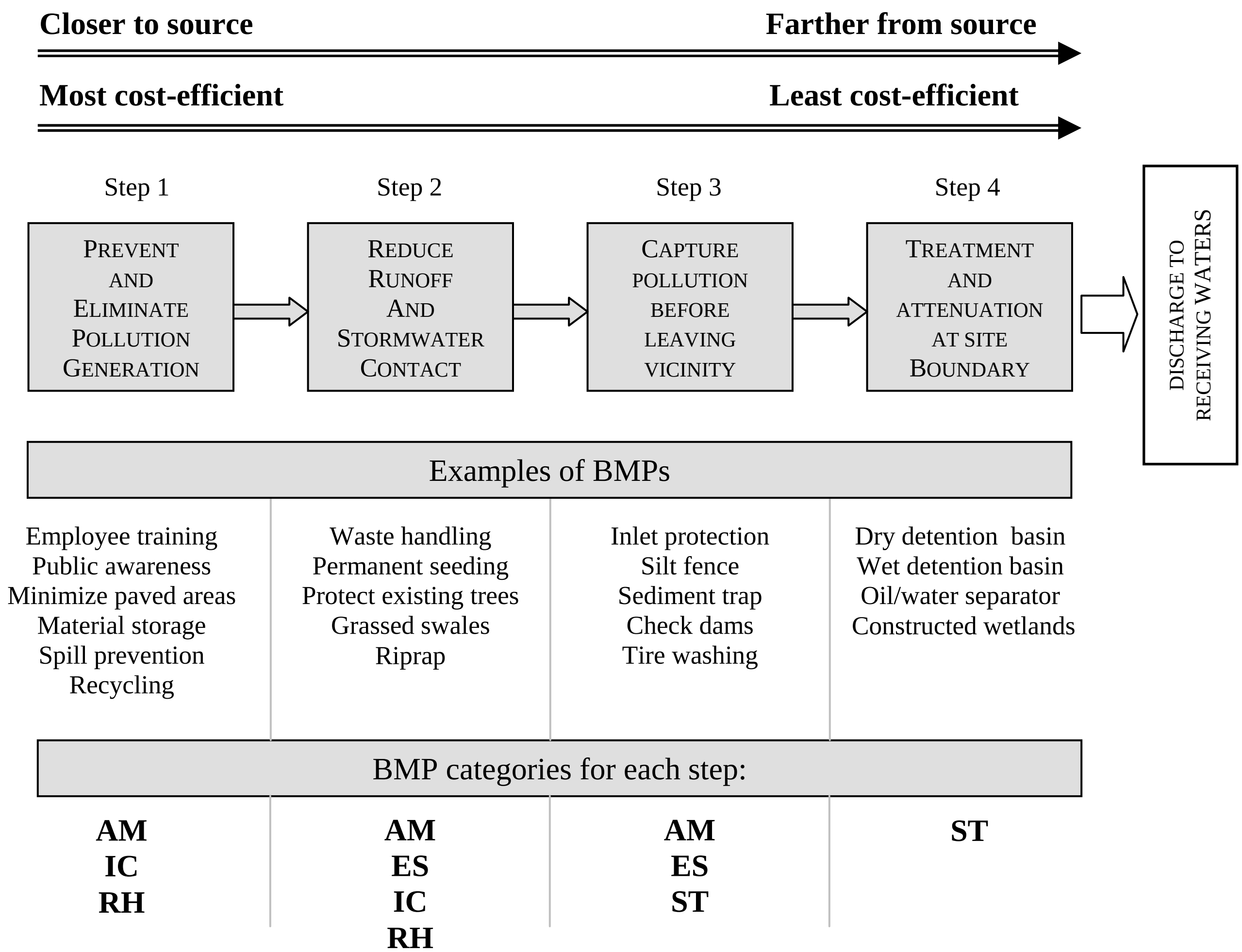
- Identify wetlands, springs, sinkholes, floodplains, floodways, sensitive areas, or buffers, which must not be disturbed, as well as other areas where site improvements will not be constructed. Establish clearing limits around these areas to prevent disturbance by the construction activity.

- Identify the boundaries of tributary areas for each outfall location. Then calculate the approximate area of each tributary area. Define areas where various contractor activities have a likely risk of causing a runoff or pollutant discharge.

With this site map in hand, categories of BMPs can be selected and located. Detailed planning before construction begins and phasing construction activities achieve erosion and pollution prevention most cost-effectively. It is more cost-effective to prevent erosion and pollution than it is to remove sediment and pollutants. This is demonstrated in Figure 4-1 by first attempting to eliminate erosion and pollution generation (step 1) prior to reviewing the other alternatives in steps 2 through 4.

BMPs that can achieve multiple BMP objectives should be utilized to achieve cost-effective solutions. For instance, it is not always necessary to install extensive sediment trapping controls during initial grading. In fact, sediment trapping should be used only as a short-term measure for active construction areas and replaced by permanent stabilization measures as soon as possible. A permanent detention pond may be built first and used as temporary sediment control by placing a filter on the outlet. After construction is complete and the tributary area is stabilized, the permanent outlet configuration can be reestablished.

Figure 4-1
BMP Treatment Options



4.4 Factors for Construction Sites

Certain contractor activities may cause pollution if not properly managed. Not all BMPs will apply to every construction site, however, all of the suggested BMPs should be evaluated. Considerations for selecting BMPs for contractor activities include the following:

- Is it expected to rain? BMPs may be different on rainy days versus dry days, winter versus summer, etc. For instance, a material storage area may be covered with a tarp during the rainy season, but not in the summer. However, it should be noted that plans should be made for some amount of rain even if it is not expected to generate a flooding event.

- How much material is used? Less-intensive BMP implementation may be necessary if a "small" amount of pollutant containing material is used. However, remember that some materials may be more dangerous or have the potential to cause widespread pollution.

- How much water is used? The more water used and wastewater generated, the more likely that pollutants transported by this water will reach the stormwater system or be transported offsite. Washing out one concrete truck on a flat area of the site may be sufficient (as long as the concrete is safely removed later), but a pit should be constructed if several trucks will be washed out at the same site.

- What are the site conditions? BMPs selected will differ depending on whether the activity is conducted on a slope or flat ground, near a stormwater structure or watercourse, etc. Anticipating problems and conducting activities away from environmentally sensitive areas will reduce the cost and inconvenience of performing certain BMPs.

- In general, establishing a BMP for each conceivable pollutant discharge may be very costly and significantly disrupt construction. As a rule of thumb, establish controls for common (daily or weekly) activities and be prepared to respond quickly to accidents. This rule of thumb only applies to contractors handling unusual materials that are not usually at the project site. Industries and commercial facilities are expected to have contingency plans and spill measures for every material that is used regularly.

Therefore, keep in mind that the BMPs for contractor activities are suggested practices, which may or may not apply in every case. Construction personnel should be instructed to develop additional or alternative BMPs, which are more cost-effective for a particular project. The best BMP is a construction work force aware of the pollution potential of their activities and committed to a clean worksite.

4.5 Stormwater Treatment Removal Goals

Various BMPs will have different rates of effectiveness. For most BMPs, the goal is to discharge clear stormwater with no visible pollutants and no known sources of man-made pollution (such as toxic substances, chemicals or fertilizers). The objective of this section is to establish a baseline for pollution removal goals to evaluate the stormwater treatment BMPs (**ST**), especially manufactured BMP systems, oil/water separators, or other innovative methods of treating stormwater runoff.

There is essentially a three-step approach to achieving water quality (simplified from the 4 steps shown in the BMP treatment train for Figure 4-1). The first step is large-scale prevention of pollution from entering or even contacting any stormwater runoff (**AM**, **ES, IC, RH**). The second step is removal of the visible components of stormwater runoff pollution, such as coarse sediment, oil and grease, bulk materials, and floating debris (**AM**, **ES**, **IC**, **ST**). The third step is the treatment and removal of the less obvious pollutants in stormwater runoff, such as fine sediment, nutrients, and heavy metals from automotive emissions (**ST**).

The City of Knoxville requires that the “first flush” volume must be detained and treated in some manner. The first flush represents the early stages of a storm event, which usually delivers a large amount of accumulated pollutants and sediments that have been deposited since the last storm event. In actuality, it is not possible to predict the manner in which rainfall will come. The first flush may be a steady drizzle that slowly dissolves oil, grease or other automotive combustion byproducts from the streets, or it may be a heavy downpour that really does flush all sediments and accumulated particulates down the storm drain.

First flush requirements are taken from the Stormwater and Street Ordinance (Chapter 22.5 of Knoxville City Code), which can be viewed on pulldown menu from city webpages or as part of the Land Development Manual. The first flush volume is defined as one-half inch of direct runoff over the entire contributing drainage area (22.5-4) with a minimum value of 4500 cubic feet (22.5-36). First flush volume is released over a minimum time period of 24 hours (22.5-36).

As a frame of reference, first flush volumes are widely required throughout the United States and generally depend on the types of local rainfall patterns. The mean annual storm for the Knoxville area was computed by CDM to be 0.53 inches (reference 152), using 44 years of hourly rainfall data from the Knoxville airport. CDM also estimated that there is an average of 74 storms per year. The average storm precipitation depth for the Knoxville area is estimated at 0.6 to 0.7 inches using a national map in reference 140. Table 4-1 shows one of nine national rainfall zones, to show relative sizes and how a summer storm might differ from the average.

Table 4-1
Representative Rainfall Statistics for Zone 2
(DE, MD, KY, NC, TN, VA, WV, and parts of IL, IN, OH)

	Mean volume	Mean intensity	Mean duration	Mean interval between storms
Annual	0.36 inches	0.066 in/hour	5.9 hours	77 hours
Summer	0.40 inches	0.101 in/hour	4.2 hours	77 hours

The following table represents a mechanism for estimating the amount of annual precipitation that is captured by an extended dry detention basin, based upon computer modeling performed by CDM using the US Army Corps of Engineers program STORM (reference 152):

Table 4-2
Percentage of Capture for Average Annual Stormwater Runoff
(based on computer modeling by CDM for Knoxville area)

Storage (inches)	Percent imperviousness for contributing watershed (I)					
	I = 0%	**I = 20%**	**I = 40%**	**I = 60%**	**I = 80%**	**I = 100%**
0.20	94%	77%	62%	52%	44%	38%
0.40	100%	94%	86%	77%	69%	62%
0.60	100%	99%	94%	89%	83%	77%
0.80	100%	100%	98%	94%	90%	86%
1.00	100%	100%	99%	97%	94%	91%
1.50	100%	100%	100%	100%	99%	97%

The overall basis for evaluating pollution removal efficiencies for various stormwater treatment BMPs is shown in Figure 4-2 (taken from reference 152). These six categories represent some of the common pollutants found in an urban environment, with the principal category considered to be the total suspended sediments (also known as total suspended solids or TSS).

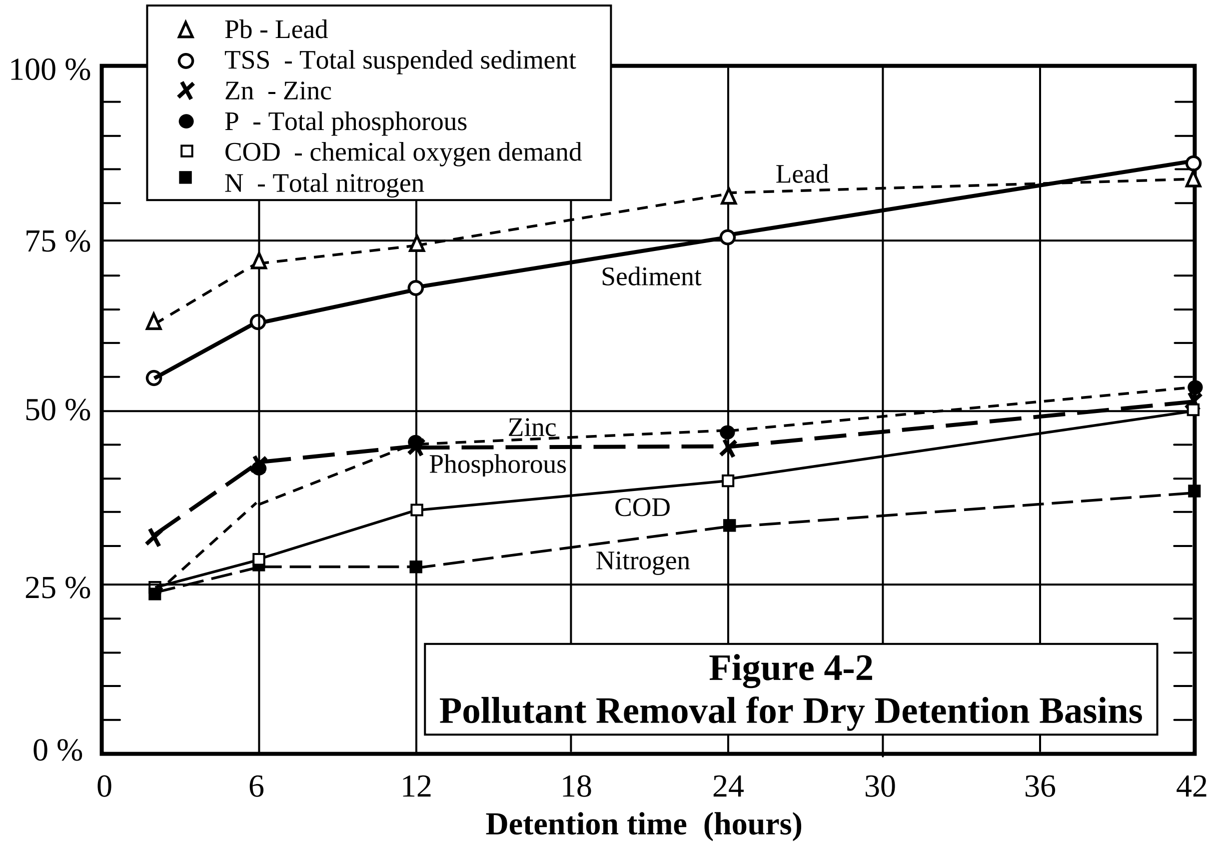


Figure 4-2
Pollutant Removal for Dry Detention Basins

Pollutant removal rates for a 24-hour detention time in Figure 4-2 are used to evaluate other stormwater treatment methods, since stormwater detention and first flush volumes are required for most new construction and redevelopment projects in the City of Knoxville. An approximate 75% removal rate is indicated for suspended sediment at a detention time of 24 hours. Dissolved nutrients (phosphorous and nitrogen) are much harder to remove from stormwater runoff, and a removal rate of 30% to 40% is reasonable for a detention time of 24 hours. A closer look shows that even 2 hours of detention time will accomplish a great deal of stormwater treatment.

Typical pollutants from areas that carry automobile traffic (such as highways, streets and parking lots) are shown in Table 4-3. Toxic pollutants such as polychlorinated biphenyls (PCBs) may also be present. Heavy metals, oil and grease, and coarse sediments can be removed efficiently through the use of oil/water separators or by media filtration inlets, provided that these manufactured systems are carefully chosen for each application.

Table 4-3
Typical Pollutants from Highways and Streets
(from reference 40)

Sources	Parameters	Average concentration mg / l	Range of concentration mg / l
Particulates: (tires, brake pads, car exhaust, mud)	Total suspended solids (TSS)	261	4 - 1656
	Total volatile solids (TVS)	242	26 - 1522
Heavy Metals: (tires, brake pads, motor oil, rust, leaded fuel, additives to other types of vehicle fluids)	Cadmium (Cd)	0.04	0.01 - 0.40
	Copper (Cu)	0.10	0.01 - 0.88
	Chromium (Cr)	0.04	0.01 - 0.14
	Iron (Fe)	10.3	0.10 - 45
	Lead (Pb)	0.96	0.02 - 13
	Nickel (Ni)	9.92	0.10 - 49
	Zinc (Zn)	0.41	0.01 - 3.4
Organic Matter: (vegetation, litter, food, animal droppings, fuel and oil)	Biological oxygen demand (BOD_5)	24	2 - 133
	Chemical oxygen demand (COD)	15	5 - 1058
	Oil and grease	9.5	1 - 104
	Total organic carbon (TOC)	41	5 - 290
Nutrients: (fertilizers, natural soils, chemicals)	Total kjeldahl nitrogen (TKN)	3.0	0.10 - 14
	Phosphorous (expressed as PO_4)	0.8	0.05 - 3.5

Table 4-4 shows the expected pollution concentration for three typical land uses, based upon published data (1993) from the National Urban Runoff Program at many locations throughout the United States. These values are for illustrative purposes only, due to the many variables involved. The total water hardness and the amount of stormwater runoff dilution are major factors in determining concentrations. Table 4-5 shows a representative range of efficiencies for several types of stormwater treatment BMPs. These efficiencies are typical for well-constructed detention basins and other structures that are properly inspected and maintained in good working order.

Table 4-4
Pollutant Concentration in Urban Runoff for Annual Exceedance Frequencies
(from reference 166)

	Residential			**Mixed Land Use**			**Commercial**		
Pollutant	**25 %**	**10 %**	**1 %**	**25 %**	**10 %**	**1 %**	**25 %**	**10 %**	**1 %**
	(pollutants are measured in mg/l for each annual exceedance frequency)								
COD	103	141	241	93	130	228	63	97	199
Lead	0.23	0.34	0.68	0.23	0.42	1.22	0.16	0.23	0.44
Zinc	0.22	0.34	0.47	0.25	0.37	0.77	0.41	0.69	1.7

Table 4-5
Comparative Pollutant Removal Percentages of Urban BMP Designs
(from reference 101)

BMP DESIGN	TSS	Total P	Total N	Oxygen demand	Trace metals
	(expressed in percentages)				
Dry detention basin, First flush held for 6 to 12 hours	60 – 80	20 – 40	20 – 40	20 – 40	40 – 60
Dry detention basin, 1” runoff volume held for 24 hours	80 - 100	40 – 60	20 – 40	40 – 60	60 – 80
Dry detention basin with shallow marsh and forebay, 1” runoff volume held for 24 hours	80 - 100	60 – 80	40 – 60	40 – 60	60 – 80
Wet detention basin, Permanent pool = 0.5” per impervious acre	60 – 80	40 – 60	20 – 40	20 – 40	20 – 40
Wet detention basin, Permanent pool = 2.5 x mean storm runoff	60 – 80	40 – 60	20 – 40	20 – 40	60 – 80
Wet detention basin, Permanent pool = 4.0 x mean storm runoff	80 - 100	60 – 80	40 – 60	40 – 60	60 – 80
Infiltration basin, Exfiltrates 0.5” per impervious acre	60 – 80	40 – 60	40 – 60	60 – 80	40 – 60
Infiltration basin, Exfiltrates 1” per impervious acre	80 - 100	40 – 60	40 – 60	60 – 80	80 - 100
Infiltration basin, Exfiltrates all runoff from 2-year design storm	80 - 100	60 – 80	60 – 80	80 - 100	80 - 100
Filter strip, 20’ wide turf strip	20 – 40	0 - 20	0 - 20	0 - 20	20 – 40
Filter strip, 100’ wide forested buffer with level spreader	80 - 100	40 – 60	40 – 60	60 – 80	80 - 100
Grass swale, Moderate slopes with no check dams	0 - 20	0 - 20	0 - 20	0 - 20	0 - 20
Grass swale, Low slopes with check dams	20 – 40	20 – 40	20 – 40	20 – 40	0 - 20
Water quality inlet or oil/water separator, (consult manufacturer)	Varies	Varies	Varies	Varies	Varies